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Terminal Market Storage of Florida Oranges

By

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Division of Fruit and Vegetable Crops and Diseases

Report of a study made under the
Research and Marketing Act of 1946
Project No. 143

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TERMINAL MARKET STORAGE OF FLORIDA ORANGES

By

James S. Wiant and Paul I. Harding

Introduction

This is a report on the storage of two car-loads of Florida oranges at northern terminal markets during the spring and summer of 1949 and is one phase of an investigation on the storage of citrus fruits that is being conducted as a project under the Research and Marketing Act of 1946. The study was conducted under the leadership of the late D. F. Fisher, and was made possible through the cooperation of the individuals and organizations listed on the last page of this report.

Information on History of Fruit, Treatments, Transportation and Storage

The two car-loads of fruit were similar to and consisted of the normal run of orchard sizes. The division of sizes was made in the packing house and the packed boxes were stacked in tiers of four boxes each, according to the size of the fruit. The division of the boxes for the two car-loads was made by trucking alternate stacks of four boxes into one or the other of two pre-cooled rooms. Therefore, each car-load was made up of practically the same number of boxes of each of the orchard run sizes.

Their history follows:

Variety	Valencia Oranges
Rootstock	Rough Lemon
Grower	Chase and Company
Location of Grower and Packing House	Isleworth, Windermere, Fla.
Fruit Picked	May 4, 1949.
Fruit Packed	May 5, 1949.
Fruit Pre-cooled	Fourteen hours - temperature reduced from 74° to 56° F.
Treatment	Gassed with ethylene sixteen hours, May 4 and 5, 1949. Packed in Bruce wirebound boxes with Phenodor (diphenyl) liners.

The cars were loaded with 525 boxes each between 2:30 p.m. and 5:00 p.m. of May 6, 1949. Temperatures inside the cars at time of opening for loading were 64° for one and 68° for the other, and the outside air temperatures ranged between 84° and 88° F. The two refrigerator cars were brand new and were equipped with fans. They were shipped May 6 from Isleworth, Florida, under Special Refrigeration Service, Item 90, Section 2, with fans sealed in "on" position. Both cars were routed ACL, RF&P, PRR, to New York City, where one was unloaded. The other car continued on the New Haven Railroad for unloading at Providence, Rhode Island.

The New York car (FGEX-39315) arrived with vents closed, plugs in, drains clear and with bunkers respectively four-eighths and five-eighths full, and with fans sealed in "on" position. The car was unloaded on Pier No. 28, North River, about 1:00 a.m., May 10, 1940, and the fruit placed in storage about ten hours later. Forty-nine crates were rejected on account of breakage. These boxes could have been re-coopered, but it was felt advisable not to include them in the storage test. A Ryan thermometer in a crate at top doorway position of the car recorded a gradual drop in temperature from 66° to 51° F. during the transit period. Following unloading the temperature rose to 57° by the time the fruit was placed in storage. The storage room was approximately 70 x 100 x 10-1/2 feet in size. Refrigeration was supplied from a brine coil bunker room by forced air circulation from overhead ducts. The boxes were stowed on their sides, three layers deep on pallets, that in turn were stacked two high. Other lots of oranges, apples, and other deciduous fruits also were stored in the room. There was frequent movement of produce into and out of the room during the storage period. Air temperatures in the immediate vicinity of the carload under observation ranged mostly from 33° to 35° and averaged 34°. The relative humidity was rather uniformly about 85 percent.

The Providence car (FGEX-39316) arrived with vents closed, plugs in, drains clear, bunkers three-fourths full, and with fans sealed in "on" position. The car was unloaded directly into storage around noon on May 10. Thirty-six crates were rejected on account of breakage. The Ryan thermometer at the top doorway position of the car recorded a gradual drop from 64° to 43° during the transit period. The storage room at Providence was approximately 94 x 51 x 10 feet in size. Only citrus was stored in the room, and there was relatively infrequent movement of fruit into and out of the room. Refrigeration was furnished by circulated brine through overhead coils. There was no forced air circulation in the room. The boxes were stowed on their sides three layers deep on pallets. The temperature of the storage room was held very uniformly at 31° to 32° F. with a relative humidity of 90 percent.

The two car-loads of oranges were held in storage for 12 weeks, after which they were sold. Throughout the entire period they were handled in a regular commercial manner. However, frequent inspections of the fruit were made to determine whether decay or any type of skin breakdown was developing. Relatively small amounts of decay were found at all inspections; skin breakdown was not of commercial importance at any time. Even at the end of the storage period the oranges were fresh, firm, and of good appearance. No apparent differences developed between the fruit stored at Providence and that stored at New York City.

At the start of the test and at the end of 7, 10, and 12 weeks of storage, six boxes representing as many sizes were taken from each of the two car-loads, for detailed inspection and study of behavior following removal from storage. The boxes from the Providence car were shipped to New York City by refrigerated truck which left late in the afternoon and arrived late in the forenoon the following day. The seven-day holding period was dated from the time the boxes were received at the New York laboratory.

Table 1
Decay in Car FGE-39315 -
Stored at New York City

Size of Fruit	Decay Per Box: At Removal %	Total After 3 Days at 70° F. %	Total After 7 Days at 70° F. %
At Beginning of Storage Period			
126	0	0	0.8
150	0	0	0.7
176	0.6	1.7	2.3
200	0.5	0.5	4.5
216	0.5	2.8	4.6
250	0	0.4	2.0
Average	0.3	1.0	2.7
After 7 weeks Storage			
126	1.6	1.6	7.1
126	0.8	0.8	8.0
126	0.8	1.6	18.2
126	0.8	0.8	17.5
150	0	0.7	14.0
176	0	0	6.3
176	0.6	0.6	11.9
176	1.7	2.2	13.1
176	0	0	11.4
200	1.0	2.0	9.5
216	0	0	9.3
216	0.9	1.8	9.7
216	0.9	2.3	9.3
216	0	0.5	15.3
250	0.8	2.0	16.4
Average	0.6	1.2	11.8

Table 1 (Continued)

Decay in Car FGX-39315 - Stored
at New York City

After 10 Weeks Storage

1[illegible]	0	0.8	18.3
150	0.7	1.3	15.3
176	0.3	3.4	15.9
200	0	2.0	14.5
216	0.5	1.9	13.9
250	0.8	2.0	14.4
Average	0.7	2.0	15.1

After 12 Weeks Storage

12[illegible]	0	4.8	24.6
12[illegible]	1.6	11.9	35.7
126	0	10.3	34.1
126	0	0.8	15.9
150	1.3	2.0	31.3
176	0	3.4	18.8
176	0	1.1	24.4
176	0.6	3.4	23.3
176	0.6	2.3	17.0
200	0.5	2.0	18.0
216	2.8	5.6	24.5
216	0.9	1.9	27.8
216	0.0	0.9	20.4
216	2.8	3.7	21.9
250	1.4	2.8	22.0
Average	1.0	3.5	23.5

In addition, three boxes of each of three sizes were removed from the New York car-load at the end of 7 weeks and 12 weeks respectively. The boxes were taken to the New York laboratory, where the phenodor liners were removed and discarded, and the fruit examined for evidence of decay and skin breakdown. The decayed oranges were removed, the sound ones repacked, and the boxes set in a storage room maintained at a constant temperature of 70°. A similar inspection was made three days later, after which the boxes were returned to the 70° room for a final inspection at the end of a seven-day period (i.e. four days after the first inspection).

Development of Decay in Relation to Storage

A record of the total decay is given in tables 1 and 2. It should be mentioned that the percent total decay indicated after three and seven days was cumulative and included the decayed fruit that was discarded at the previous inspections.

It will be seen that for the most part relatively little decay was found at the time the boxes were removed from storage - even after twelve weeks storage. Only moderate amounts of decay developed during the three-day holding period at 70° F. However, after seven days at 70° decay had increased to a considerable extent. This was especially noticeable in the later inspections. The relationship of decay development to length of the storage period and to length of the holding period following removal from storage is shown graphically in figure 1.

Approximately three-quarters of the decay was stem-end rot; the remainder was chiefly Penicillium rot (blue mold rot and green mold rot). In the boxes removed after twelve weeks storage Alternaria rot was conspicuous at the button and caused a dry rot affecting chiefly the rind in the immediate vicinity of the button. This was particularly prevalent in the New York car.

Rind Breakdown in Relation to Storage

Skin breakdown was of little importance. The observers were of the opinion that the small amount present was not of commercial significance. With the exception of somewhat higher percentages of decay in the fruit stored at New York City (tables 1 and 2, and figure 1), there was no discernible difference between the fruit from the two cars.

Sale of Storage Fruit at Providence and New York City

Storage of both car-loads was terminated at the end of twelve weeks. The fruit at Providence was removed from storage in several lots and sold during the week of August 1 to 8. The fruit was held at a 38° to 40° cold room at the commission merchant's while sales were made from samples on display. The prices received were in the neighborhood of $7 for size 126; $8 for 150's; $8.50 for 176's, 200's, and 216's; and $7.50 for the 250's. The average price received for the entire car-load was $8.08 per box.

Table 2
Decay in Car FGB-30315 - Stored
at Providence

Size of Fruit		Per Box: At Removal %	Per Box: Total After 3 Days at 70° F. %	Per Box: Total After 7 Days at 70° F. %
		At Beginning of Storage Period		
126		0	0.8	5.6
150		0	0.7	[illegible]
176		0	1.7	[illegible]
200		0.5	2.0	4.5
216		0	0.9	2.8
250		0	1.6	2.8
	Average	0.1	1.3	3.5
		After 7 Weeks Storage		
126		0	0.8	1.6
150		0.7	0.7	6.0
176		1.1	2.3	7.9
200		1.0	1.0	6.5
216		0.9	1.9	8.3
250		1.2	2.0	4.4
	Average	0.9	1.5	6.0
		After 10 Weeks Storage		
126		0	3.2	22.6
150		0.7	1.3	16.0
176		0.6	0.6	8.7
200		0.5	1.5	11.0
216		1.9	2.8	11.1
250		2.0	2.9	8.8
	Average	1.1	2.1	13.1
		After 12 Weeks Storage		
126		1.6	7.1	18.3
150		0	2.0	10.7
176		0.6	1.1	10.2
200		0	0	14.0
216		0.9	1.4	14.4
250		0.8	2.0	8.6
	Average	0.6	2.0	12.5

The New York fruit was removed from storage early in the morning of August 2 and sold at auction on Pier 28 the same day. The average price received was $9.69 per box. This compares very favorably with the New York City market price for California oranges sold on that day. In table 3 is shown the average price per box (based on an average of all brands for each size) received for 49 car-loads of California oranges sold at auction on August 2 and 87 car-loads sold on August 1, and for the Florida car-load stored at New York. These represent practically all of the oranges sold at New York on those days. The data in this table show that the stored car-load of Florida oranges out-sold California fruit by approximately $4.50 per box. However, about half of this price differential appears to be accounted for by the greater prevalence of small sizes in the California fruit.

The results presented in this report indicate that Florida oranges can be successfully stored three months at Providence and New York City, and successfully sold at auction on the open market. The economic advantage of storing Florida fruit is indicated by the higher price received after twelve weeks in storage. When placed in storage on May 10 Florida fruit similar to the storage lots sold at Providence for $5.06 and at New York for $6.12 as compared with $8.08 and $9.68 after storage.

Decay and Volume of Juice After Storage in Relation to Size of Fruit

The commercial storage of the car-load lots afforded opportunity to study the relationship of size of fruit to decay and volume of juice. The investigation included two holding tests at 70° F., conducted on the fruit after 7 and 12 weeks in commercial storage. The lots were drawn from the New York City storage and each test was made up of four boxes each of oranges of sizes 126, 176, and 216.

At the end of the holding period the fruit was inspected for decay and the data averaged. The results indicate that no relationship exists between the development of decay and size of oranges. The tabulated data are shown in table 4.

The amount of juice was determined on samples of twenty-five oranges from the fruit that had been in cold storage for three months and held one week at 70°. The investigation was made on different sized fruit from both the Providence and the New York car-loads. Results are shown in figure 2.

The data show that both the weight of a twenty-five-orange sample and the weight of juice decreased with decrease in the size of the oranges. In both instances weights were slightly lower in the samples from the New York carlot than in comparable sized fruit from the Providence carlot. This may have been due to the lower humidity prevailing in the New York storage room.

Table 3
Summary of Orange Sales
New York City, August 1 and 2, 1940

Size	August 1 87 California Cars No. of Boxes	August 1 87 California Cars Price 1/	August 2 40 California Cars No. of Boxes	August 2 40 California Cars Price 1/	August 2 Florida car-lot Stored at New York No. of Boxes	August 2 Florida car-lot Stored at New York Price
100	35	$ 7.07	-	$ -	-	$ -
126	218	8.16	37	8.20	28	7.50
150	633	7.98	192	8.14	128	9.15 & 9.20
176	1272	7.80	608	8.19	96	10.35 & 10.40
200	1974	7.65	1461	7.74	65	10.50 & 10.55
216	-	-	-	-	96	10.30 & 10.35
220	3277	6.91	3100	7.00	-	-
250	-	-	-	-	24	8.50
252	4145	5.39	4047	5.18	-	-
288	4195	4.40	5173	4.13	7	6.30
344	2650	3.76	3662	3.75	-	-
392	712	3.61	870	3.53	-	-
Average		5.27	Average	5.14	Average	9.68

1/ An arithmetical average of all average prices listed for each brand of each car.

Table 4
Relationship of Decay to
Size of Fruit

Size	Decay at Removal	Decay after three days at 70° F.	Decay after seven days at 70° F.
	%	%	%
	Seven Weeks Storage		
126	0.9	1.2	12.7
176	0.6	1.0	10.7
216	0.5	1.2	10.9
	Twelve Weeks Storage		
126	0.4	7.0	27.6
176	0.3	2.6	20.9
216	1.9	3.0	23.6

The gallons of juice per standard box (1-3/5 bushel) were calculated from the data plotted in figure 2. The results are given in figure 3 and show that the volume of juice per crate of oranges tends to increase slightly with decrease in the size of the fruit. Thus, juice per crate was lowest for 126 size fruit and highest for 250 size. An exception occurred with the 216 size fruit, which yielded less juice per crate than either the 200 or 250 size. No explanation is offered for this discrepancy. Volume of juice per crate was consistently somewhat lower in the samples from the New York car.

Modified Holding Test

In former years the keeping quality of citrus fruits has been determined by the percentages of rind breakdown and total decay, when the fruit is removed from cold storage and after a seven-day holding period at 70° F. Since the seven-day holding period is rather a severe test, in these studies an inspection was made after three days at 70 as well as at time of removal and after seven days. Another modification in the holding test tried on a small scale in these studies was the exposure of the fruit to open air temperature of about 80° F. for a period of 24 hours following removal from cold storage and then storing it at home refrigerator temperatures of about 45° F. The keeping quality of the fruit was determined by frequent removal and inspection of fruit. Six crates of oranges from the lot stored at Providence for 12 weeks were used for this test. The results of inspections made after 1, 2, 5, 9, 12 and 16 days are presented in figure 4. Since the percentages of decay that developed at 45° were so small, after the ninth day half of the fruit was transferred to 70 for the rest of the holding period. Decay developed rapidly in the lots transferred to 70° F., there being 7.2 percent decay after 3 days and 31.6 percent decay after six days. In contrast, the lots at 45° storage showed 2.2 and 3.3 percent total decay respectively on the same dates.

Cooperators:
Randall Chase, Sydney Chase, Frank W. Chase, Robert H. Reely, Corbett Hutchinson - Chase & Company, Sanford, Florida.
B. E. Yaden, and H. V. Keeler - Yaden, Keeler and Young, New York City.
P. F. Robison and Orluf R. Elting - A. M. Tourtellot & Company, Providence, Rhode Island.
P. B. Christensen, E. F. Mann and J. Hayes - Merchants Refrigerating Company, New York City.
Arnold T. Hampson, George W. Boutilier and T. F. Fisher - Merchants Cold Storage and Warehouse Company, Providence, Rhode Island.
H. C. Diehl - The Refrigeration Research Foundation, Berkeley, California.
D. F. Fisher and H. T. Cook, U. S. Department of Agriculture, Beltsville, Maryland.
Paul H. Harding, Bryan Sunday, Randall Cubbedge, G. Lee Roberts, G. A. Meckstroth - U. S. Department of Agriculture, Orlando, Florida.
James S. Wiant, W. A. Radspinner, B. A. Friedman, J. Kaufman, H. W. Hruschka, and Robert Shallenberger - U. S. Department of Agriculture, New York City.

Figure 1. Summary of Decay
In Stored Carloads

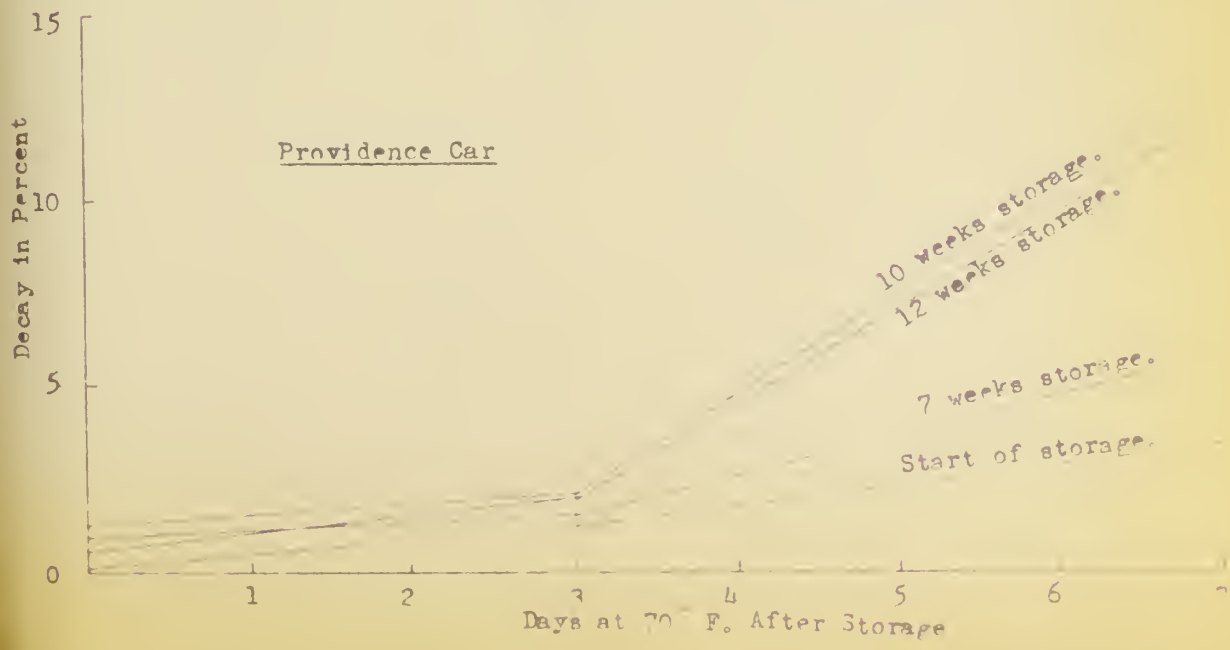


Figure 2. Weight of 25-orange samples and weight of juice from 25-orange samples in relation to size of fruit.

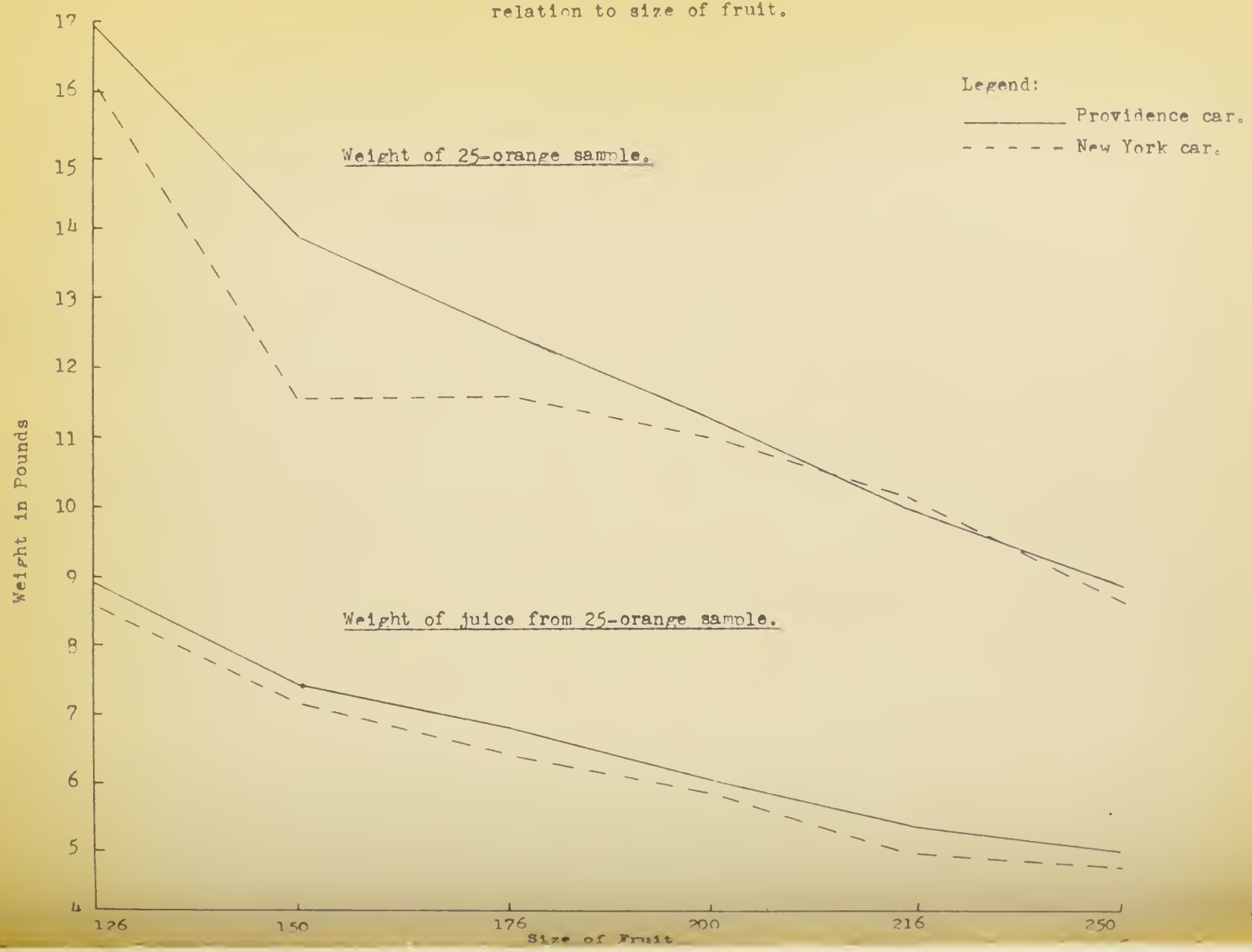


Figure 3. Volume of Juice per Box
In Relation to Size of Fruit.

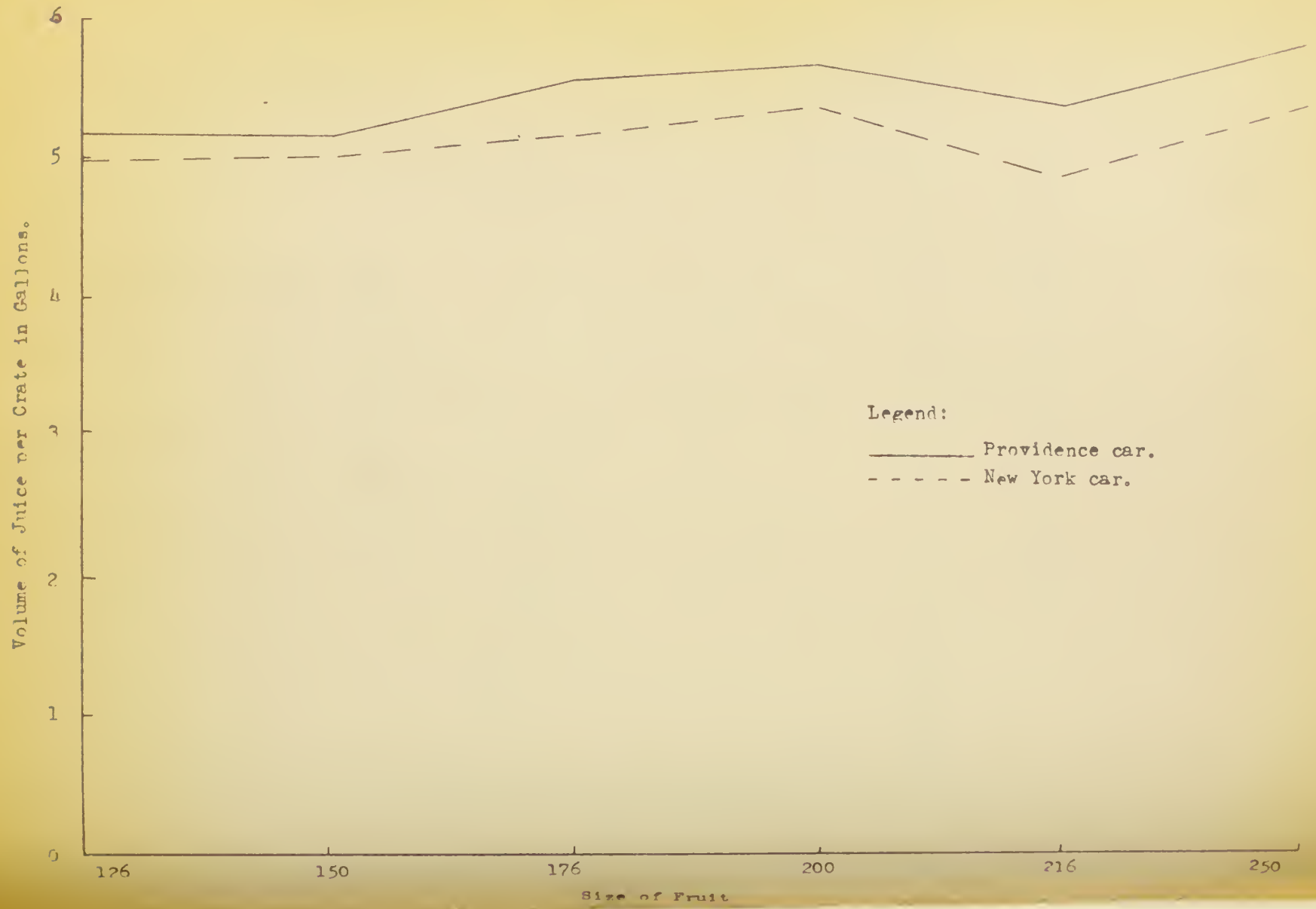
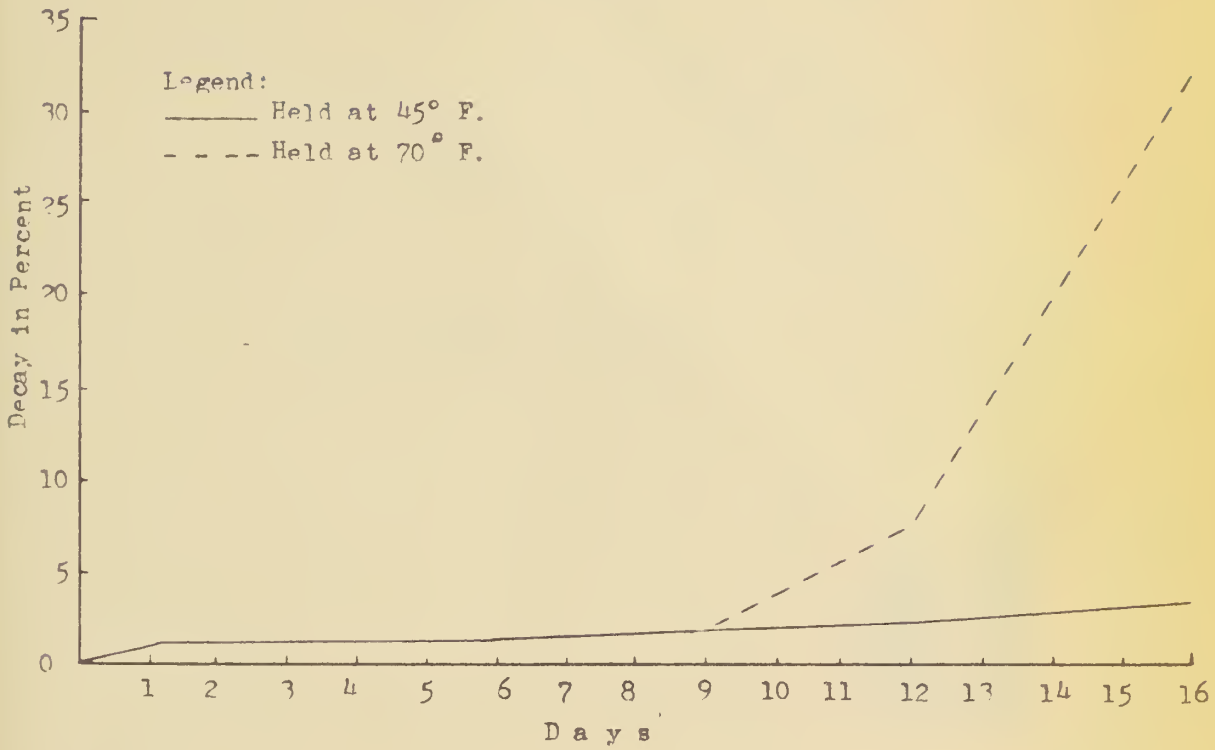


Figure 4. Summary of Decay
in Modified Holding Test.



Length of Storage Period at Specified
Temperatures Following One Day at 80°F.